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Hydrological implications of vegetation change in a subarctic, alpine catchment, Yukon Territory, Canada

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As a result of altitude and latitude amplified impacts of climate change, widespread alterations in vegetation composition, density and distribution are widely observed across the circumpolar north. The influence of this vegetation change on the timing and magnitude of hydrological fluxes is uncertain, and is confounded by changes driven by increased temperatures and altered precipitation (P) regimes. In northern alpine catchments, quantification of total evapotranspiration (ET) and evaporative partitioning across a range of elevation-based ecosystems is critical for predicting water yield under change, yet remains challenging due to coupled environmental and phenological controls on transpiration (T). In this work, we analyze 6 years of surface energy balance, ET, and sap flow data at three sites along an elevational gradient in a subarctic, alpine catchment near Whitehorse, Yukon Territory, Canada. These sites provide a space-for-time evaluation of vegetation shifts and include: 1) a low-elevation boreal white spruce forest (~20 m), 2) a mid-elevation subalpine taiga comprised of tall willow (Salix) and birch (Betula) shrubs (~1-3 m) and 3) a high-elevation subalpine taiga with shorter shrub cover (< 0.75 m) and moss, lichen, and bare rock. Specific objectives are to 1) evaluate interannual ET dynamics within and among sites under different precipitation regimes , and 2) assess the influence of vegetation type and structure, phenology, soil and meteorological controls on ET dynamics and partitioning. Eddy covariance and sap flow sensors operated year-round at the forest and during the growing season at the mid-elevation site on both willow and birch shrubs for two years. Growing season ET decreased and interannual variability increased with elevation, with June to August ET totals of 250 (±3) mm at Forest, 192 (±9) mm at the tall shrub site, and 180 (± 26) mm at the short shrub site. Comparatively, AET:P ratios were the highest and most variable at the forest (2.4 ± 0.3) and similar at the tall and short shrub (1.2 ± 0.1). At the forest, net radiation was the primary control on ET, and 55% was direct T from white spruce. At the shrub sites, monthly ET rates were similar except during the peak growing season when T at the tall shrub site comprised 89% of ET, resulting in greater total water loss. Soil moisture strongly influenced T at the forest, suggesting the potential for moisture stress, yet not at the shrub sites where there was no moisture limitation. Results indicate that elevation advances in treeline will increase overall ET and lower interannual variability; yet the large water deficit during summer implies a strong reliance on early spring snowmelt recharge to sustain soil moisture. Changes in shrub height and density will increase ET primarily during the mid-growing season. This work supports the assertion that predicted changes in vegetation type and structure will have a considerable impact on water partitioning in northern regions, and will also vary in a multifaceted way in response to changing temperature and P

regimes.